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Saudi Arabia's Domestic Energy Situation and Policy: Focusing on Its Power Sector

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1. Introduction

Saudi Arabia was formally established in 1932 by King Abd al-Aziz ibn Abd al-Rahman ibn Faisal Al Saud. The new nation's principal industries at that time were commerce, oasis farming and nomadic herding, and governmental revenue depended on the taxation of hajj pilgrims and foreign aid from the United Kingdom. The Great Depression that hit the world economy in the 30's caused a significant decrease in pilgrims, and the Saudi treasury was on the verge of bankruptcy when vast reserves of oil were discovered in the Eastern Province in 1938. This new found oil wealth provided the government with a stable income, and Saudi Arabia rose to become a major oil producing country wielding a strong influence over the world economy.

An American oil company, Aramco, commenced intensive and rapid infrastructure development in Dammam to extract, produce, and export the oil. This included building a town in the desert and a port, with interconnecting roads, utility supplies, housing and a market for workers. By 1939, Saudi Arabia had begun to export oil. From 1970, Saudi Arabia began a 5 Year Development Plan to pursue what was termed "Modernization without Westernization" as instructed by the 3rd king, Faisal bin Abd al-Aziz Al Saud. Today, the Saudi people enjoy a modern infrastructure, free education, free health-care and a high standard of living comparable to developed countries. We can safely say that Saudi Arabia has accomplished its "modernization", and this achievement was made possible by the production and export of oil.

Since Saudi Arabia is a major and influential oil producing country, its production capability, reserves and national security risks are discussed frequently. However, its domestic energy economy has attracted little attention. How does Saudi Arabia use energy? What is its energy infrastructure like? What is the current situation? These are the questions we will attempt to answer in this article by examining the history, policy, detailed situation and issues related to Saudi Arabia's domestic energy use, focusing on electricity.

2. Domestic Energy Demand Structure and Energy Efficiency

This section covers both primary energy and secondary energy in Saudi Arabia. Primary energy can be defined as natural resources for fuel, such as crude oil, coal and gas, while secondary energy is derived from primary energy by refining it for practical use in the form of

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electricity, petroleum products and so on.

2.1. Energy Supply and Local Consumption

Figure 1 shows the local consumption and export of Saudi crude oil [SAMA 2010]. Until around 1990, local consumption increased and leveled off at 20–30% of production, 700–900 million barrels, which is used in Saudi Arabia. Even in the period of low world oil demand, the decline in local consumption was small. It is clear that total oil production depends not on local needs but on the world's economic circumstances. In 2009 Saudi Arabia consumed 2.61 million barrels per day and was the 6th largest consumer in the world as shown in Table 1 [BP 2011].¹

Figure 1: Crude Oil Export & Local Consumption [SAMA 2010]

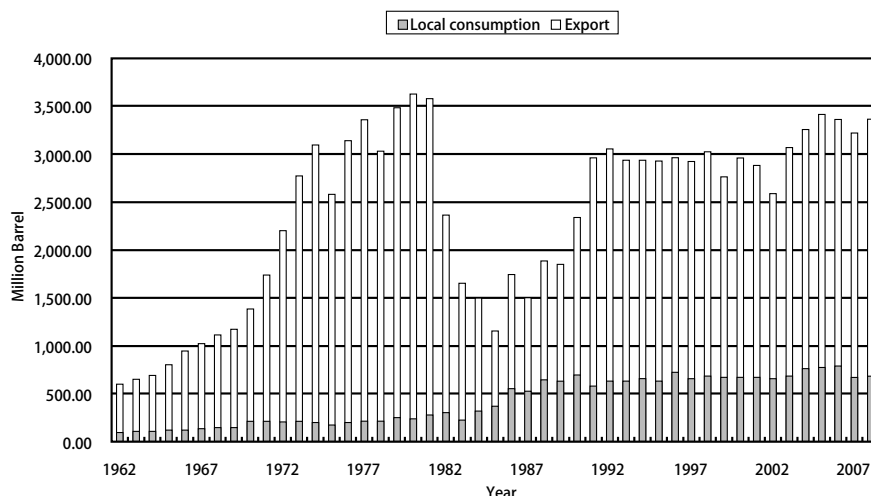


Table 1: Crude Oil Consumption in 2009 [BP 2011]

	Country	Crude Oil Consumption (Million barrel/day)
1	United States	18.69
2	China	8.63
3	Japan	4.40
4	India	3.18
5	Russia	2.70
6	Saudi Arabia	2.61

Saudi Arabia also has reserves of another primary energy source, natural gas.² As shown in Figure 2, all the natural gas has been consumed locally, except for flare burning and re-injection into oil fields to increase production [MEP 2011]. Until the beginning of the 1980s

¹ Saudi proven oil reserves in 2009 were 264.6 billion barrels and the largest (19.8%) in the world [BP 2011].

² 86% of natural gas is associated with oil production [Al-Yousef & Stevens 2011].

flaring gas was common but from 1984 gas has been utilized effectively and flaring has decreased. On the other hand, re-injection has been increasing recently.³ Saudi Arabia's proven reserves are 7,920 billion m³ (4.2% of the world) and its local consumption ranks 9th in the world [BP 2011] as shown in Table 2.

Figure 2: Natural Gas Production & Consumption [MEP 2011]

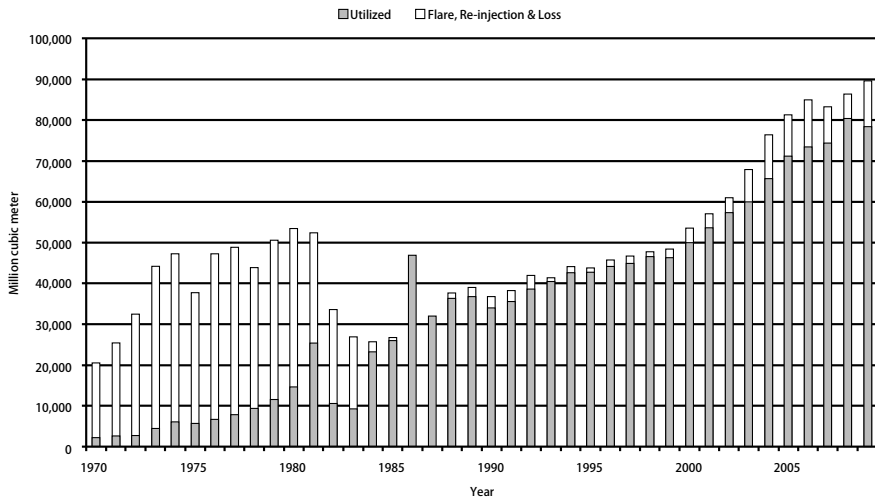


Table 2: Natural Gas Consumption in 2009 [BP 2011]

	Country	Natural Gas Consumption (Billion m ³)
1	United States	646.6
2	Russia	389.7
3	Iran	131.7
4	Canada	94.7
5	China	88.7
6	Japan	87.4
7	United Kingdom	86.5
8	Germany	78.0
9	Saudi Arabia	77.5

2.2. Local Demand Structure

Saudi Arabia's primary and secondary energy flow can be illustrated as shown in Figure 3 and Figure 4 respectively [IEA 2010]. Its input is about 556 million toe⁴ in total, 497 million toe of crude oil, 55.08 million toe of natural gas (Figure 3) and 3.85 million toe of

³ Increase of re-injection means no flowing caused by low pressure of an oil field and is a warning of a well drying up.

⁴ toe is "ton of oil equivalent" and a unit of energy given by combusting 1 ton of crude oil. 1 toe is approximately 42 gigajoules.

imported oil products (Figure 4). The national oil company, Saudi Aramco, is in charge of production, refining, supply, import and export of all the primary energy. Produced primary energy consists of 90% crude oil and 10% natural gas in toe [IEA 2010]. 70% of crude oil (346 million toe) in primary energy and 61.39 million toe of oil products in secondary energy, which is transformed from 20.6% of crude oil at refineries, are exported. The local consumption of energy equals all the natural gas (55.08 million toe) plus 30% of crude oil (151 million toe) plus imported oil products (3.85 million toe) minus the above exported oil products, which comes to 148 million toe.

Figure 3: Primary Energy Flow in 2007 [IEA 2010]

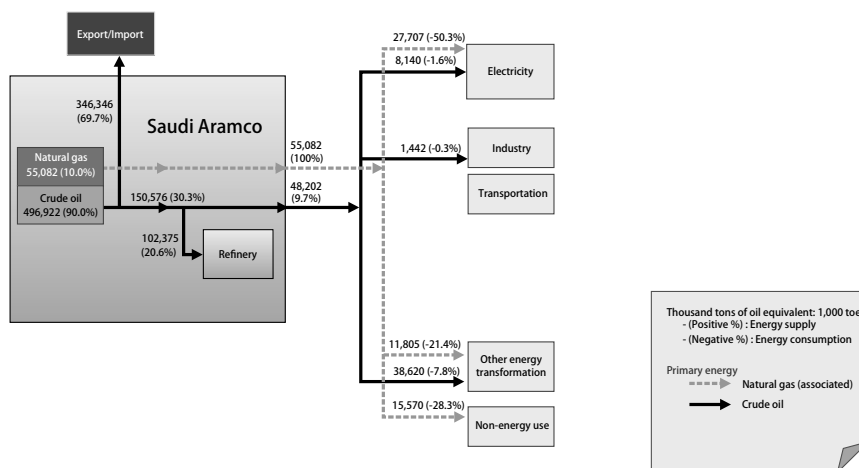
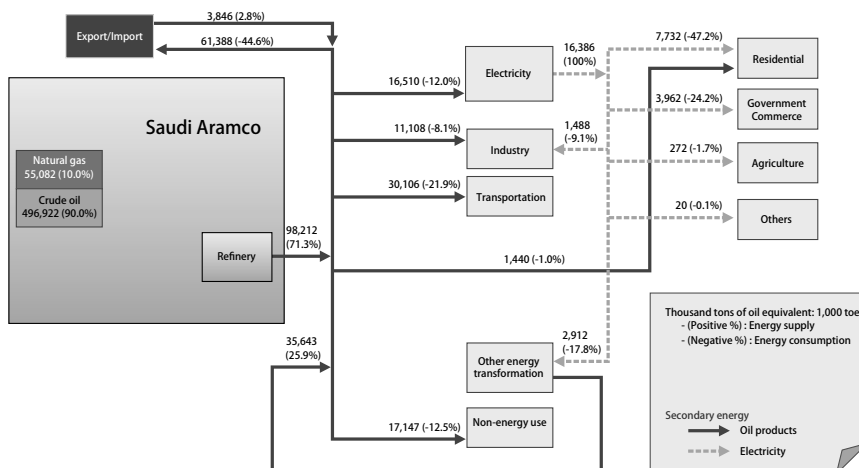


Figure 4: Secondary Energy Flow in 2007 [IEA 2010]

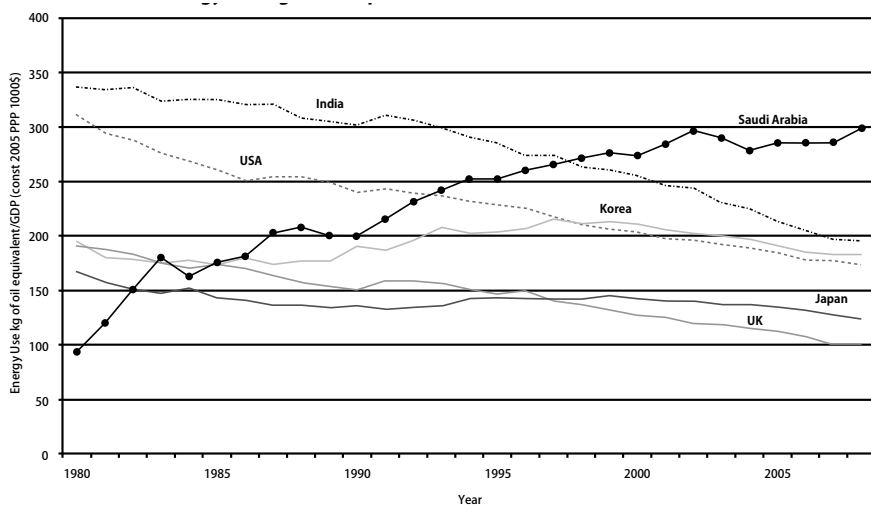


As shown in Figure 3, half of natural gas is used for power generation and the rest is consumed in other forms of energy transformation such as heat plants and refining, and non-energy use. The main non-energy user is the petrochemical industry. 22% of refined oil products are used in the transportation sector. The state power company, Saudi Electricity Company (SEC), generates 16.39 million toe of electricity (secondary energy) which corresponds to 11% of total local consumption. Almost half of the power demand (47%) is consumed by the residential sector, 24% by government and commerce, and only 9% of electricity is used by the industrial sector. As can be seen here, the specific feature of Saudi electricity use is a small industrial demand⁵ and a large non-industrial one, especially in the residential sector.

2.3. Energy Efficiency and Consumption per Capita

Figure 5 shows the trend of energy (kg oil equivalent: kg-oe) use per GDP for some countries, such as developed UK, USA and Japan, developing Korea and India, and Saudi Arabia [World Bank 2011; IEA 2004; 2005a–2010].

Figure 5: Energy Efficiency of Selected Countries [World Bank 2011; IEA 2004; 2005a–2010]



A smaller value means that 1,000 USD value is produced with less energy and better energy efficiency as a country. Japan was the most efficient and has remained almost stable but from 1997 the UK's production became more efficient than Japan's. Developed and developing countries are on the downside, that is improving efficiency, but Saudi Arabia showed a soaring trend until 2002, when it became stable, but it is still less efficient than other countries. In the 1980s Saudi Arabia's oil income was measured against a smaller population

⁵ Industry consumes only 8.1% of oil products and 0.3% of crude oil.

and lower energy consumption, so it was more efficient than the other energy producers. However since then, the growth of its energy demands has exceeded its GDP growth, and its efficiency has worsened. Saudi efficiency rate was 300 kg-oe/1,000USD in 2008, 2.4 times less efficient than Japan (124 kg-oe/1,000USD).

Figure 6: Energy Consumption (kg-oe) per Capita [World Bank 2011]

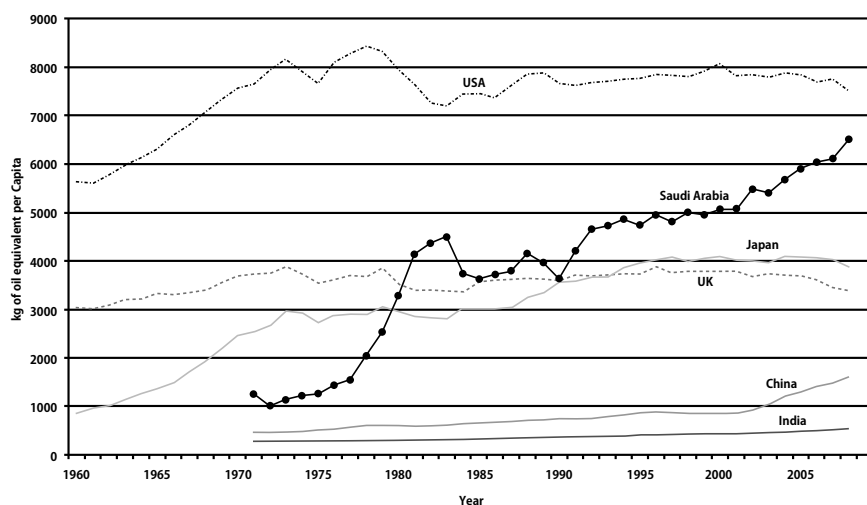


Figure 7: kWh per Capita [World Bank 2011]

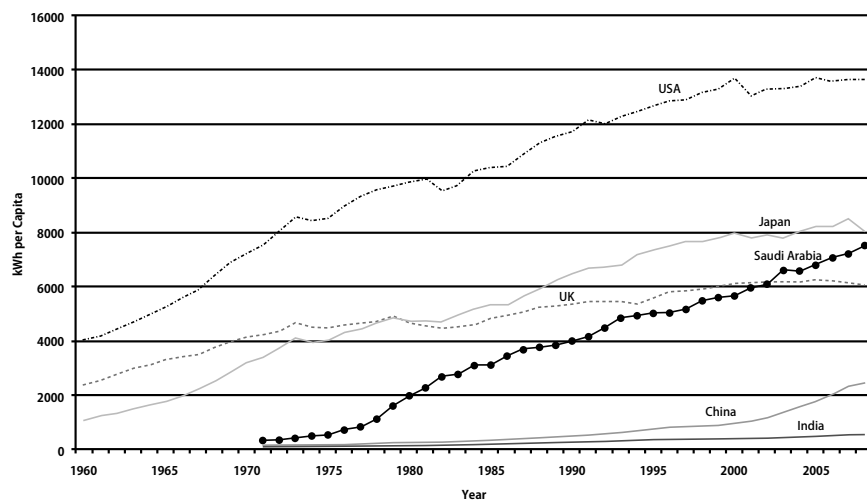


Figure 6 shows energy consumption (kg-oe) per capita [World Bank 2011]. Americans consume a lot of energy but consumption has become stable. On the other hand, Saudis have used a rapidly increasing amount, especially in the latter half of 1970s for establishing basic infrastructures and a modern life style. Domestic consumption continued to rise during the

oil depression from 1983 to 1990. The Saudis consumed 6,514 kg-oe in 2008, 1,7 times more than the Japanese (3,882 kg-oe) and per capita consumption is still increasing. China and India also show increases but their absolute values are small as are their growth rates. Figure 7 shows electricity consumption (kW) per capita [World Bank 2011]. The growth rate of Saudi Arabia has been large and presently the Saudis are consuming 7,527 kWh, which is similar to the Japanese (8,071 kWh).

From these analyses, we can say that as an oil producing nation, Saudi Arabia has an increasing local oil demand accompanied by worsening energy efficiency and its people make lavish use of energy. The per capita consumption is similar to or larger than developed countries and this situation is an indication of a modernized Saudi society.

3. Desalination

Although the energy demand structure is shown in the previous section, there is one more important and implicit factor, that is, the water supply. 80–90% of water is supplied by non-renewable groundwater [Abderrahman 2001a]. In 1997, there were 85,000 wells and they were used mainly for irrigation in agriculture (16.41 billion m³). On the other hand, residential and industrial zones (2.06 billion m³) are supplied by desalination plants as shown in Table 3.⁶

Saudi Arabia's ratio of desalinated water use is just a few percent, much smaller than the over 40% consumed in the UAE and Kuwait, but its plant capacity is 2,2 billion m³ and is the largest in the world [IEA 2005b; Abderrahman 2001b].

Table 3: Water Supply in Saudi Arabia [Abderrahman 2001a]

Million m ³	1990	1992	1997
Surface water and shallow aquifers (renewable)	2,100 (13.0%)	2,140 (7.0%)	2,140 (12.0%)
Groundwater (non-renewable)	24,489 (83.0%)	28,576 (90.0%)	15,376 (83.0%)
Desalination	540 (3.0%)	795 (2.0%)	795 (4.0%)
Treated waste water treatment	110 (0.7%)	185 (0.6%)	185 (1.0%)
Total	27,239	31,696	18,496

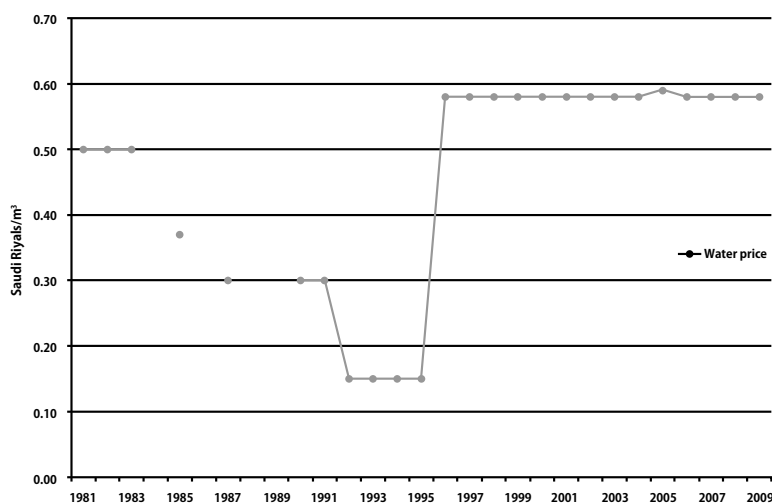
As pumps are used to obtain groundwater and desalination plants are operated by oil and gas, a huge amount of energy is used to obtain water in Saudi Arabia. That is, water as a Basic Human Need is not available without oil. To desalinate seawater, the Multi-Stage Flash (MSF) and the Reverse Osmosis (RO) processes are widely used. MSF heats up and boils seawater, and potable water is produced by cooling down the generated steam. In the RO process, pressurized seawater is pumped through a reverse osmosis membrane and potable water is

⁶ Priorities in water supply in Saudi Arabia are (1) residential, (2) animal, (3) agriculture, (4) industry and (5) others [Abderrahman 2001a].

leached out by condensation and disposing of saline matter. In the MSF process, 2–4 kWh or more of electricity for heat input is needed to obtain 1 m³ of water and in the RO process, 3–8 kWh of electricity is required [IEA 2005b]. To pump up groundwater, 0.4–0.8 kWh of electricity is necessary [Abderrahman 2001b]. Assuming 3 kWh/m³ for MSF, 5.5 kWh/m³ for RO and 0.6 kWh/m³ for pumping up groundwater, the annual power consumption is approx. 13.13 GWh based on the supplied quantity in Table 3 and it corresponds to 8.6% of the total generation of SEC (153.28 GWh).

The desalination process consumes not only electricity but also gas/oil as fuel to boil water especially in the MSF process. Total consumed primary and secondary energy is 11 million toe which comes to 8.4% of Saudi energy consumption, 130 million toe [IEA 2005b]. The cost of desalination is 2.6 SR⁷ (0.69 USD) and transmission & distribution cost via pipeline is 5.5–6.6 SR [Abderrahman 2001a: 71].⁸

Figure 8: Water Price in Saudi Arabia [CDSI 1982–2010]



However water price is set very low. Figure 8 shows the change in water price since 1981 [CDSI 1982–2010]. It was very cheap at the beginning of the 1990s, but now it's 0.58 SR/m³. However, it is still just 0.15 USD/m³ which is 1/8 to 1/4 of the rate in Kuwait (0.65 USD/m³) and Qatar (1.20 USD/m³) which also depend on desalination [IEA 2005b]. The difference between the production cost and the price is covered by a governmental subsidy which amounted to 3.2 billion USD, 7% of the oil exporting income in 2005 [World Bank 2005].

⁷ Saudi Riyal, 1USD = 3.75SR

⁸ Concerning the desalination costs, there are some figures available. The Electricity & Co-Generation Regulatory Authority (ECRA) in Saudi Arabia reveals that it is 2.25 SR/m³ in the East coast zone, 2.29 SR/m³ in the West coast, 15.97 SR/m³ in small-scale plants, 1.33 SR/m³ in transmission, and the cost of electricity as a by-product is 57.3 Halala/kWh (1SR = 100Halala) (2009).

As mentioned earlier, groundwater used for agriculture is non-renewable. Even though new underground water sources may be found in the future, existing wells are drying up. IEA estimates 1/3 of existing wells have dried up and all the groundwater in Saudi Arabia will disappear within 15–20 years [IEA 2005b]. Because of a modernized life style and rapid population growth in its cities, Saudi Arabia will inevitably depend on desalination more and more and consequently it will be even more heavily dependent on oil.

4. Power Sector

4.1. A Brief Historical Review

Saudi Arabia's electricity industry began as a private enterprise. The 1930s witnessed the introduction of electricity generation as some entrepreneur's needed it for their businesses. They were also able to sell their excess capacity to neighboring houses and for street lighting. In 1949, some Saudi businessmen cooperated to establish the first private electricity company in Dammam [Wilson & Al-Rajhi 2004]. In those days Dammam in the Eastern Province was the hub of the newborn oil business and the home of the American oil company, Aramco,⁹ which needed basic infrastructure and utility supplies. In this business environment, the first power company was established to supply electricity to Aramco related businesses and residential zones.

From the 1950s, small-scale generating plants and power companies were established independently in some cities.¹⁰ They were not publicly-owned or managed by the government, but purely profit-making businesses that set independent tariffs.

In 1961 the Department of Electricity Affairs was established in the Ministry of Commerce and started administrative work on legislation and licensing. Based on King Faisal's declaration "Electricity for Every Person", the Department of Electricity Services was spun off from the Ministry in 1972 and began planning works for electricity supply. The department was consolidated with the Ministry of Commerce and Industry¹¹ and named the Industry and Electricity Agency in 1974, and in 1975 the Ministry was renamed the Ministry of Industry and Electricity (MIE). MIE was responsible for planning the overall expansion of power sources and the supply grid but the power companies themselves were widespread, small-scale, regional monopolies and thus operated inefficiently. Then the government started to consolidate power companies, to change them into semi-governmental organizations and to set a unified tariff across the country. By 1981, four Saudi Consolidated Electricity Companies (SCECOs) were established in the East, West, South and Central provinces, and after some delay small power companies in the Northern province were also consolidated. Table 4 shows the government's shares in each SCECO [Wilson & Al-Rajhi 2004].

⁹ Aramco was nationalized in 1980 and renamed to Saudi Aramco.

¹⁰ The first power company in Riyadh was operated by Britain.

¹¹ Formerly the Ministry of Commerce.

Table 4: Government's Share in SCECOs in 1999 [Wilson & Al-Rajhi 2004]

in Million SR	Central	Western	Eastern	Southern	Northern	Total
Paid-up capital	8,000	7,350	4,151	3,564	37	23,102
Government share	5,742	6,281	3,764	3,513	21	19,322
Percent	72	85	91*	99	57	84

* Includes Saudi Aramco share of 41 percent

In 1995 a privatization plan for the power sector was authorized and as the first step, SCECOs were consolidated into one state enterprise, Saudi Electricity Company (SEC) in 2000. Furthermore in 2001, the Electricity & Co-Generation Regulatory Authority (ECRA) was established to supervise the tariff system and grant licenses to generating companies. ECRA has promoted private investment in the power business by Independent Power Producer (IPP)'s BOO (Build, Own and Operate). In 2003, the Electricity Agency in MIE and the Water Agency in the Ministry of Agriculture were separated from their respective Ministries and incorporated into the Ministry of Water and Electricity (MoWE). The government has already made a policy to separate SEC horizontally into generation, transmission and distribution companies and since around 2010 restructuring of SEC has started in accord with this policy.

As described above, Saudi Arabia's electricity business was started by private businesses, then in the 1970s it saw governmental participation, and it was changed into state owned company plus IPP with foreign investors and is today once more under private ownership with horizontal separation.

4.2. Power Grid

Figure 9 shows SEC's power grid. The mark \triangle indicates a generating plant and a line shows a transmission line. As clearly shown in this figure, power grids for inland Najd, where Riyadh is located and the Eastern Province are connected and constitute one grid named "Central Operating Area & Eastern Operating Area (COA+EOA)". However Hijaz including Jeddah, Madinah and Makkah, and the southern Asir area have separate grids named the "Western Operating Area (WOA)" and "Southern Operating Area (SOA)" respectively. Furthermore, there are many small towns and villages in the rural area which are not connected with major power grids, and their electricity is supplied by diesel generation. The connection of COA+EOA and WOA is a long term issue and an effective network operation for this wide area has not been realized yet.^{12,13} One more issue is the widespread distribution of diesel generators in rural areas, which need fuel procurement/transportation and operation

12 In decoupled grids, each grid has to correspond to peak demand (kW) by itself but if connected widely, much more flexible operation for peak hours can be realized because each peak appears at a different time and power can be transmitted from one area to another.

13 Although Saudi Arabia has separate grids, connections with Kuwait, Bahrain and EOA were made in 2009.

& maintenance staff, for which SEC has to bear a costly burden.

Figure 9: SEC's Power Grid [SEC 2005]

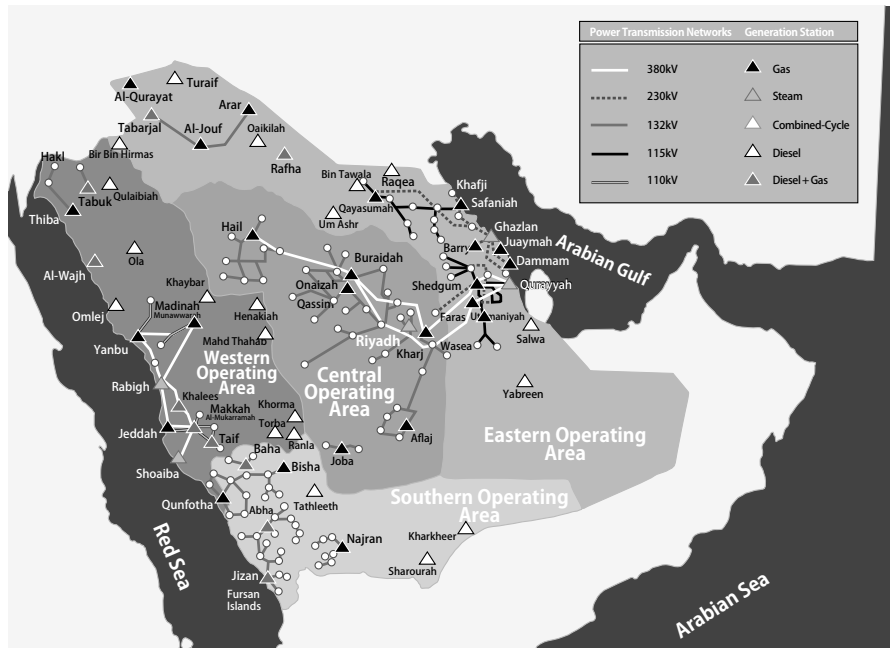


Figure 9 shows only SEC's generating plants but other companies, such as Saline Water Conversion Corporation (SWCC), and Saudi Aramco, I(W)PP,¹⁴ own plants and sell power to SEC as shown in Table 5 [ECRA 2009].

Table 5: Generating Facilities in Saudi Arabia [ECRA 2009]

Company	# of plant	Generation capacity (MW)
SEC	50	40,366
SWCC	12	5,135
Tihamah Power Generation Co.	4	1,083
Marafiq (Yanbu)	1	1,033
Saudi Aramco	6	1,018
Saudi Cement Company	2	266
Jubail Water and Power Co.	1	733
Shuaibah Water and Power Co.	1	1,191
Jubail Power Co.	1	250
Rabigh IWPP	1	120
Total	79	51,195

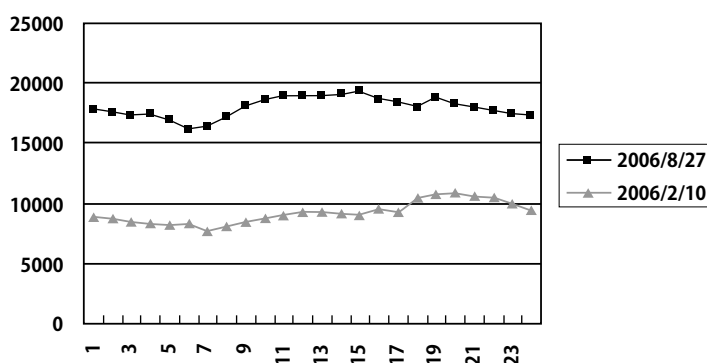
¹⁴ I(W)PP is IPP and/or IWPP which stands for Independent Water and Power Producer.

4.3. Power Demand

4.3.1. Daily Load Curve

A daily load curve is a plotted graph of max demanded power (MW) for every hour of the day. Daily consumed energy (MWh) is the area under the plotted graph. Daily load curves of COA+EOA with max peak (27 August, 2006) and min peak (10 February, 2006) are shown in Figure 10. The annual peak load is 19,324 MW and load variation in a day is 2,000–3,000 MW which is 10–15% of peak and smaller than Japanese 40–60%.

Figure 10: Daily Load Curve of COA+EOA in 2006
Max Load on 27 August and Min Load on 10 February [JICA 2008]



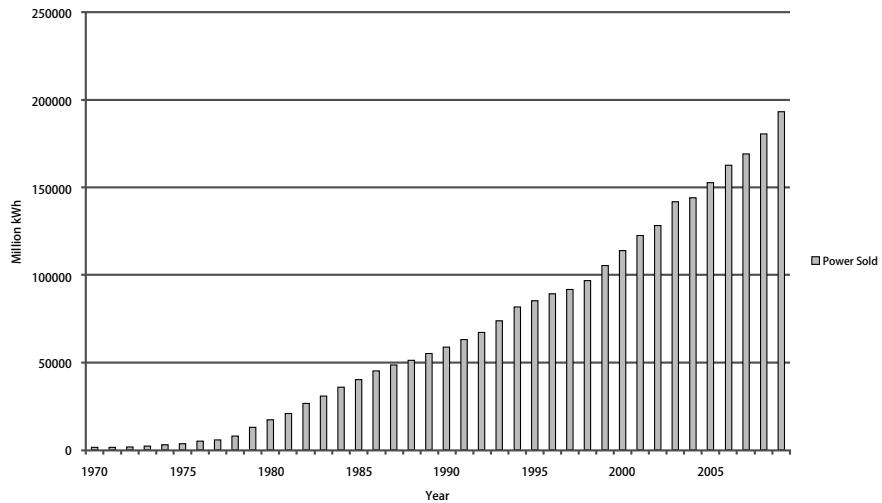
Variation in a day is not so large but the summer demand is almost twice the winter's. Thus SEC estimates that the power demand for cooling is almost equal to the difference between the max and min curve in Figure 10, that is, 10,000 MW in COA+EOA.

At peak time (3 PM) in summer, SEC has to supply 19,324 MW but at 6 AM in the morning required power is just about 16,000 MW. To meet the peak load, SEC has to have extra generators which are not needed in off-peak time. This difference affects the management of utility companies significantly, and peak-shift and peak-cut measures have become very important to maintain as flat a load curve as possible. Apart from peak-shift and peak-cut, it is important to drag down the load curve. This is done by energy conservation and has a direct link to the preservation of primary energy, but generally speaking, utility companies are not completely supportive of this policy because it causes a decline in their revenues.

4.3.2. Demand Structure

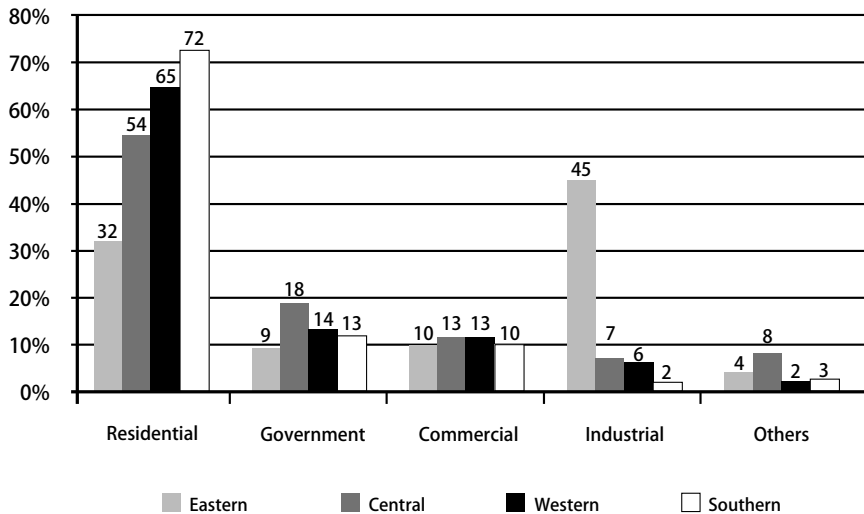
Electricity demand growth in kWh is shown in Figure 11. It was 193,500 million kWh in 2009 [SAMA 2010], and the average annual growth rate is 13.4%.

Figure 11: Sold Electricity (kWh) [SAMA 2010]



The regional breakdown of electricity demand is shown in Figure 12. About a half of the energy is consumed by the residential sector but there are differences among regions. The Western and Southern regions have higher residential demands while the Eastern Province with its oil fields has a larger industrial demand of 45% [ECRA 2009; Wilson & Al-Rajhi 2004].

Figure 12: Electricity Demand Structure in 2009 [ECRA 2009]



The structure shown in Figure 12 is the result of changes over the last 40 years. In the first half of the 1970s, the industrial sector consumed more than 60% of the electricity produced as shown in Figures 13 and 14. From the second half of the 1970s, due to

infrastructure development and the modernization of the society, consumption in the non-industrial sector grew very rapidly. Thus the growth rate of the residential sector from the 1980s is higher than the other sectors. This feature can also be observed in developed countries, but such a dramatic rate of change has not been observed in other countries. The rapid increase in residential electricity use invites an examination of the present domestic energy issue in Saudi Arabia.

Figure 13: Trend of Electricity Demand Structure [IEA 2004; 2005a–2010]

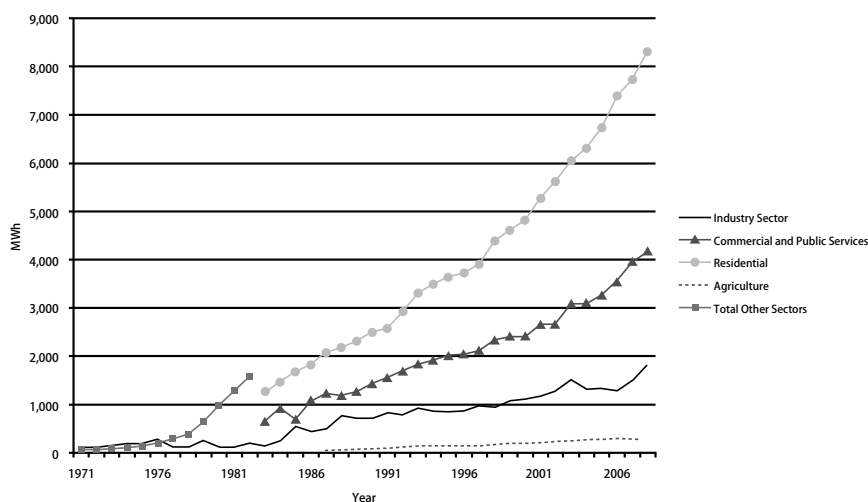
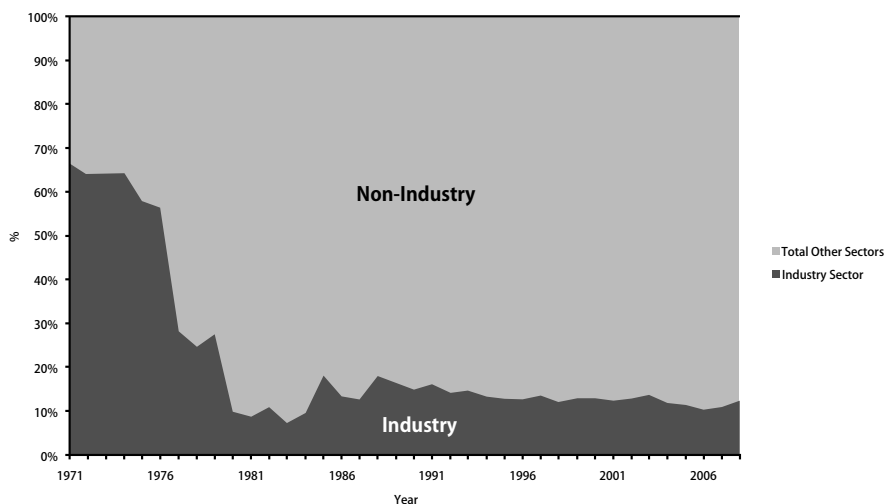


Figure 14: Ratio of Industrial and Non-industrial Demand [IEA 2004; 2005a–2010]



Industrial modernization began with increased oil consumption, while social and residential modernisation started with and requires an ever increasing supply of electricity. Today, electricity is essential to sustain a modern life style. The Bedouin Settlement Policy from the 1940s and TV broadcasting from 1965 both gave impetus to this tendency. In 1970 the First 5 Year Development Plan was started and the government embarked on an urban planning scheme. Comprehensive city planning for Riyadh was established in 1973 and it was from this moment that Saudi people demanded a modern electricity dependent life style, and it goes without saying that in the dry, torrid conditions of the desert climate, air conditioning is most important for a better quality of life. Thus electricity demands for air conditioning are very large, as mentioned earlier.

Saudi Arabia's electricity demand is unique in that it is not the industrial but the residential sector that consumes a lot. Generally, as modernization has progressed, expensive and convenient secondary energy, especially electricity, has been used to provide an increasingly comfortable life style, but in Saudi Arabia with its severe climate conditions, this has always been the first priority.

5. Issues in Power Sector

So far, the history, distribution, and demand of Saudi Arabia's power sector have been described and various issues have been mentioned. This section focuses on three major issues: the increasing demand in kWh, the growing peak demand (kW)¹⁵ and the distribution of small generators in rural areas.

The growth of electricity demand in kWh is very large and there is an urgent need to moderate it. Furthermore, as shown in Section 3, a huge amount of power and oil resources are devoted to desalination. The Ministry of Petroleum and Mineral Resources and Saudi Aramco have been expressing an urgent sense of crisis, since both water supply and power production depend on oil which is a very valuable export. If it is possible for Saudi Arabia to reduce its local oil consumption this would lead directly to an increase in foreign currency income and conservation of its limited oil and gas resources.

Figure 15 shows growth by sector. The horizontal axis is the average growth rate of energy sold between 2000–2007 and the vertical axis is average growth rate of the number of customers in that period [MoWE 2004 & 2007]. The diagonal line shows equal growth rate of both variables. In this figure, there are three positions as shown below;

(1) On the diagonal line indicates:

Consumption per customer does not change even with an increase in customers.

¹⁵ Take notice the difference between kW and kWh. kW is a measure of instantaneous power and kWh is the power used over time.

(2) The area above the diagonal line indicates:

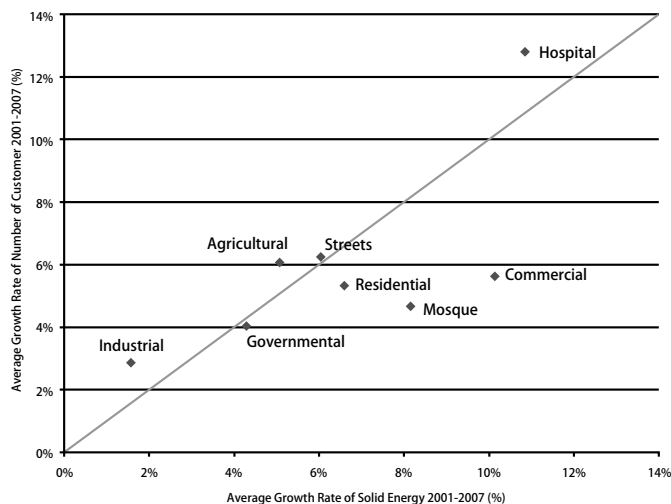
Number of customers increases more rapidly than energy sold, which means

- Decreasing consumption per customer, and possibly
- New customers consume less energy than existing ones on average (lighter users)

(3) The area below the diagonal line indicates:

- Increasing consumption per customer, and possibly
- New customers consume more energy than existing ones on average (heavier users)

Figure 15: Average Growth Rate of Sold Energy and Number of Customers [MoWE 2004 & 2007]

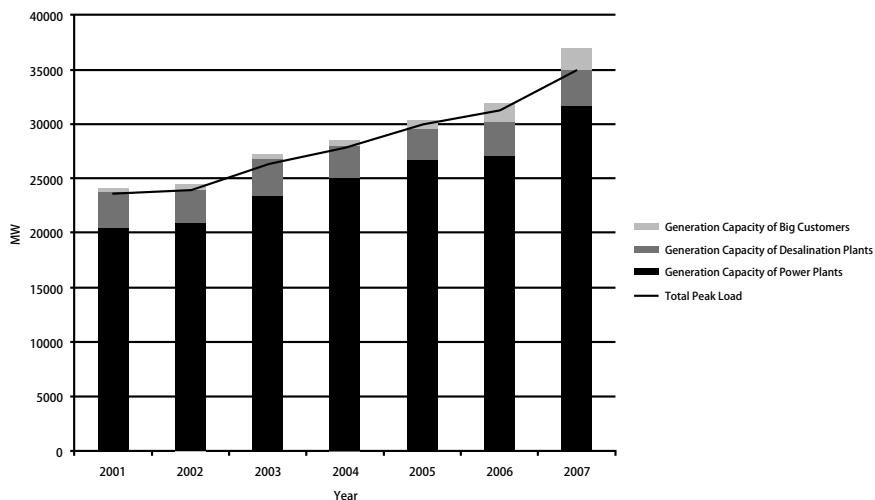


From Figure 15 we cannot deduce anything about energy efficiency, but we can see how the average consumption per customer has changed. The consumption per customer in the industry, agriculture and hospital sectors is decreasing, but in the residential, mosque and commercial sectors it is increasing. Especially in the commercial sector, there has been a 5.6% increase in number of customers vs. a 10.1% increase in energy sold. We can infer that heavy users in the commercial sector, such as high-rise buildings and shopping malls with air conditioning systems have increased. The residential sector shows a better result than the commercial sector, with a 5.3% increase in customers vs. a 6.6% increase in energy sold. However residential demand is so huge due to the growing population that it is not appropriate to neglect this small difference. In the residential sector, we can infer that new housing consumes more energy than existing housing and that maybe consumption in older houses is growing too.

In contrast, the industrial sector shows a decrease in consumption per customer. We can infer that in industrial sector new customers are lighter users than existing customers, and maybe the consumption of existing customers is decreasing too.

The power sector's second issue is a rapid growth in the peak demand (kW). The average growth rate of the peak demand is approx 14% and in 2009 the peak demand was more than 40 GW, which exceeded what could be supplied by SEC alone. This issue is an even bigger headache than the first one. In Figure 16, the bar chart shows the generating capacity and the line graph indicates the peak demand. Recently, SEC's generating capacity has not been able to cope with the growing demand and the shortage has been covered by large customers'¹⁶ own generating capability. Furthermore, in the summer peak period, SEC requests customers to switch off their supply from the grid and to operate their emergency generators, to reduce the load. One more measure for peak load periods is to link COA+EOA and WOA, which has been a long pending issue, but the connection between these grids has not been realized yet.

Figure 16: Generating Capacity and Peak Load [IEA 2002; 2004–2010]



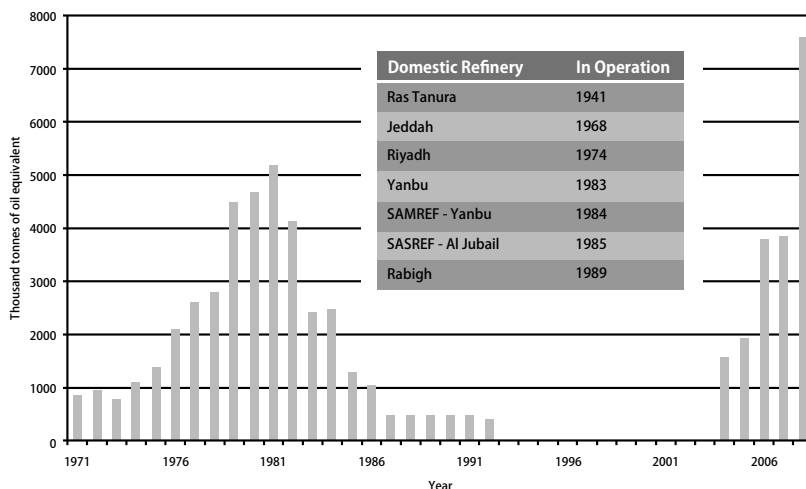
The third issue is small islands of grids powered by diesel generators in rural areas. In summer peak season there is sometimes, not enough diesel oil available to supply these generators. In Section 2.2, the import of oil products is shown. As shown in Figure 17, Saudi Arabia imported gasoline and diesel oil from abroad in the 1970s and 80s, and then, when the construction of domestic refineries such as Jeddah, Riyadh, Yambu and Al-Jubail was completed, these imports decreased and finally stopped [IEA 2004; 2005a–2010]. However since 2004, due to a shortage of diesel oil for generation in rural areas and gasoline for automobiles, Saudi Arabia has begun importing gasoline and diesel oil again and the volume is increasing, despite the fact that 61.39 million toe¹⁷ is being exported [Gulf Daily News

¹⁶ Saudi Aramco, SWCC and I(W)PP.

¹⁷ Refining of crude oil produces various oil products, such as LPG, gasoline, naphtha, diesel and fuel oil. Saudi Arabia exports heavy oil products and imports lighter ones. There is little demand for heavy fuel oil and it is supplied to the cement industry free of charge.

2009]. The Gulf Daily News reports that 16.89 million tons and 23 million tons of diesel oil were imported in 2008 and 2009 respectively [Gulf Daily News 2009]. The price of local oil products is set based on domestic oil production and refining, so it is very cheap. Oil products purchased from overseas at higher market prices and sold at cheaper local prices invite a deficit.

Figure 17: Oil Product Imports and Domestic Refineries [IEA 2004; 2005a–2010]



6. Tariff System and Subsidy

6.1. Tariff System before 1973

As described in Section 4.1, the power supply business was started by small private entrepreneurs without any regulation and who had an independent tariff system. In 1954, under the government's instructions, electricity prices were reduced; for example, in Jeddah from 55 Halala/kWh to 32.5 Halala/kWh. In 1959, by the Council of Ministers Decision (CMD174), prices in major cities were changed as shown in Table 6 [ECRA 2008]. In November 1963, a nationwide unified tariff policy was determined which required a price cut of 12% in Jeddah, 30% in Makkah and 40% in Taif. To achieve this, the government subsidized private power companies. In January 1972, Royal Decree 1099 declared the tariff system shown in Table 7. This introduced a monthly basic charge (5 SR for non-industry and 20 SR for industry) and provided governmental subsidies to assure 7% profit to power companies. In July 1973, in 16 small cities, prices were cut by 50–60% to 18 Halala/kWh for industry and 20 Halala/kWh for non-industry, and a 10% profit was guaranteed by the government to invite private investment in the power business.

Table 6: Electricity Prices in Major Cities per CMD 174 of 1959 [ECRA 2008]

	Customer except for Mosque (Halala/kWh)				Mosque (Halala/kWh)
	First 100 kWh	More than 100 kWh	First 4 hours after sunset	Past 4 hours after sunset	
Jeddah	24	21	24	18	18
Makkah	30	25	30	17	15
Madinah	30	25	30	18	15
Khobar	30	25	26	17	15
Dammam	30	25	26	17	15

Table 7: Electricity Prices in Various Cities as per Royal Decree (1099)
of 30/11/1391 AH (17/1/1972) [ECRA 2008]

Halala/kWh	Non-industrial consumption (Halala/kWh)	Industrial consumption (Halala/kWh)
Jeddah	14	13
Makkah	20	18
Taif	20	18
Madinah	20	18
Yanbu	25	20
Dammam	14	10

6.2. Tariff System after 1974

As described above, before 1973 electricity prices were 10–30 Halala/kWh and higher than at present. After 1974, 7 changes in the tariff system were made in 1984, 1985, 1992, 1995, April and October 2000 and January 2011. There was a big revision in January 2011 which broke up the non-industrial sector and introduced a Time of Use (TOU) tariff system for industry¹⁸.

(1) Non-industry

Figure 18 shows the changes in non-industrial tariffs. In this figure, from left to right, 9 tariffs are shown in chronological order. The latest is at the far right, surrounded by a dotted line which includes five tariffs for each sector. Each tariff may have different unit prices, shown in 11 bar charts, for each additional 1,000kW from left to right. Unit prices for smaller usage are cheaper.

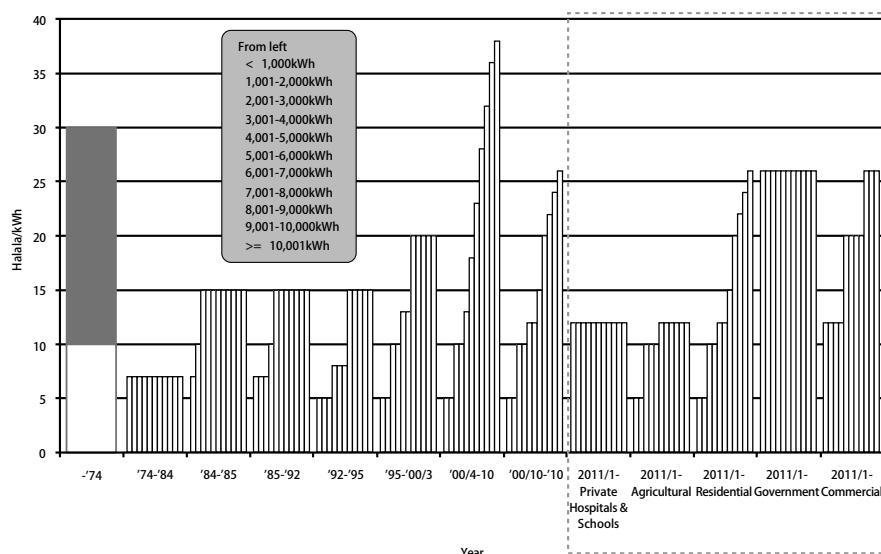
By CMD1020 in 1974, the government had shares in power companies and prices were cut to less than half (unified 7 Halala/kWh). At the very initial stage, due to regional monopolies, prices were too high, but this new, unified price setting was too low, even though

¹⁸ Here I focus on metered tariffs only. Other initial charges on power receiving contracts and meter reading tariffs (basic charge) are not discussed below.

fuel costs were cheap, causing a loss to the power companies which were then compensated by the government. Moreover, the government guaranteed the power companies a fixed profit of 15%.

From 1984 tariff, a basket system was applied to tariffs, in which the unit price was raised according to the amount of usage. It was cheaper for small users and an arrangement was made to provide a wide range of low and middle-income families at a cheap unit price. Tariff changes in 1985 and 1992 were actually reductions in price. From 1995, to strengthen the financial condition of power companies in pursuit of the privatization of the power sector, prices were raised for middle and heavy users. In April 2000, large raises were made but people complained about it, and the government was obliged to reduce prices again after 6 months.¹⁹ However, the tariff for larger consumers was 1.2 times higher than in 1995. Then, in January 2011, a tariff system for subsectors was introduced. As for private hospitals and schools, the price was set at a cheap flat rate, 12 Halala/kWh, and for agricultural users it was actually reduced to a maximum of 12 Halala/kWh. There was no change for the residential sector but the government has set a very high unit price of 26 Halala/kWh uniformly. The largest impact was on the commercial sector, particularly small business owners who had to pay more than double the previous tariff, which provoked many complaints.

Figure 18: Electricity Tariffs for Non-Industry [MoWE 2004 & 2007; ECRA 2011]



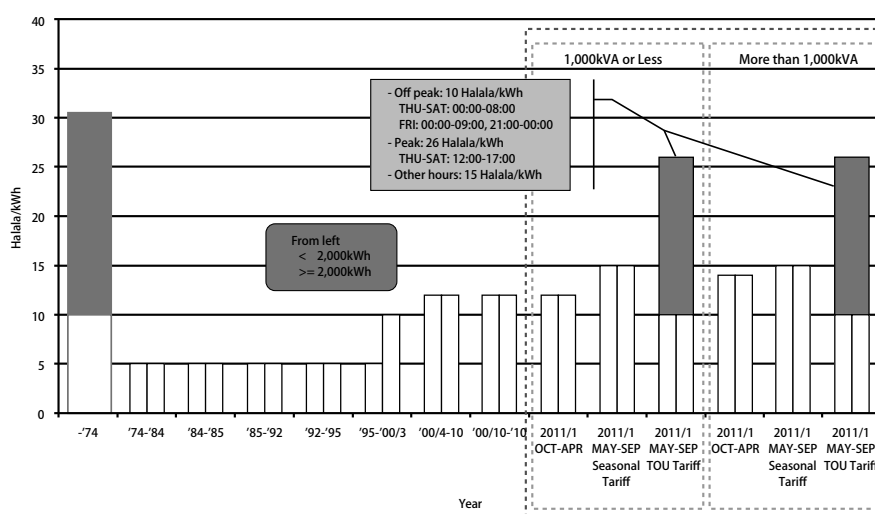
(2) Industry

Figure 19 shows the changes in the tariff system for industry and is drawn in a similar way to Figure 18. Basically it introduced a flat price without a basket system, except from 1995–2000

¹⁹ The largest protest was made by the army and commercial sector.

when there were two unit prices according to usage (less than 2,000 kWh and more). The tariff for industry was kept very low, at 5 Halala/kWh, until 1995. This was one of the government's attempts to encourage private industry growth from 1970. Especially up to 1976, as shown in Figure 14, more than 60% of electricity was consumed by the industrial sector. However, when the government reduced prices to industry in line with their policy of industrial promotion, this preferential treatment became an accomplished fact which suggests vested interests. In the 1980s and 90s, since the Ministry of Commerce and Industry or the Ministry of Industry and Electricity was the controlling authority of the power sector, power prices were only raised in non-industrial sectors until 1995, in accord with the 'industry-first' policy.

Figure 19: Electricity Tariffs for Industry [MoWE 2004 & 2007; ECRA 2011]



Finally, in January 2011, this policy was reviewed and the tariff system was changed. The present TOU²⁰ tariff was introduced for the industrial sector as shown in Table 8. Under this tariff, the unit price scale is unique: it is 12 Halala/kWh for less than 1,000 kVA and 14 Halala/kWh for more from October to April (winter), but from May to September (summer) it is 26 Halala/kWh in peak time (12:00–17:00 on Sat.-Thu.), 10 Halala/kWh in off-peak time, and 15 Halala/kWh at other times. It is necessary to install a digital meter to apply TOU, in which case the user can pay a cheaper charge by seasonal tariff or by TOU, but if a meter is not installed the user pays the charge by a seasonal tariff.

²⁰ In TOU, the unit price of electricity changes by season and time of day. Based on the total grid demand, peak time and off-peak time were defined and the unit price for each time zone and season were determined. This is designed to promote peak shift and peak cut from the demand side.

Table 8: TOU Tariffs for Non-Industry. January 2011

Consumption Period	Seasonal Tariff (EM Meters)			TOU Tariff (Digital Meters)					
	Consumption Hours	Tariff		Consumption Hours				Tariff	
		< 1000kVA	>= 1000kVA					< 1000kVA	>= 1000kVA
OCT-APR	All	12	14	All				12	14
MAY-SEP	All	15		Off-Peak Hours				10	
				Day		Hours			
				From	To	From	To		
				SAT	THU	00:00	08:00		
				FRI		00:00	09:00		
						21:00	00:00		
				Peak Hours					
				Day		Hours			
				From	To	From	To		
				SAT	THU	12:00	17:00		
				Other Hours				15	

6.3. Generation, Transmission and Distribution Cost

As shown above, the electricity price is set very low, so let's check its actual cost in this section. The 2009 Annual Report of ECRA states that average selling price per unit was 12.3 Halala/kWh while the production cost was 13.8 Halala/kWh [ECRA 2009]. However, Al-Yousef and Stevens says that the frequently quoted cost estimation is 37.2 Halala/kWh, but this is based on international traded oil prices and if the long-run marginal cost of domestically produced oil is used, it is estimated at 11.9 Halala/kWh [Al-Yousef & Stevens 2011].

Does SEC have a profit or a deficit? To check this, let's check the sales revenue and production cost of electricity based on the 2011 Annual Report of SEC. In 2010, the total annual energy sold was 212,263GWh, the revenue was 27,859.74 million SR and the production cost was 26,053.9 million SR. By ignoring the difference between fixed and variable costs, the revenue and cost per kWh come in at 13.13 Halala/kWh and 12.27 Halala/kWh respectively. This result shows that SEC doesn't have a deficit but a surplus. However, SEC receives various governmental aids to achieve these figures. One of the major aids from the government was made on the payment for fuel from Saudi Aramco. The Annual Report says, "Accounts payable to Saudi Aramco for fuel costs for the period from April 5, 2000 to December 31, 2003 have been reclassified from current liabilities to non-current liabilities (long-term government payables) in accordance with the minutes of the Ministerial meeting held between his HE the Minister of Finance and his HE the Minister of Petroleum and Mineral Resources signed on Jumada Al-Ula 15, 1427 H

whereby the Company's liability to Saudi Aramco was transferred to the account of the Ministry of Finance." Taking these supports into consideration, we infer that SEC still has a deficit.

It is very difficult to identify the electricity costs of Saudi Arabia and we cannot determine an accurate figure. Anyway, the governmental agency ECRA reports a 1.5 Halala/kWh deficit which comes to 3,260 billion SR annually, which is covered by governmental subsidies, but even in this case, the cost is not based on the international traded oil price. If less were consumed for power generation, Saudi Arabia could obtain more income by selling the oil in the international market. Therefore, increasing the financial strength of SEC is an urgent matter.

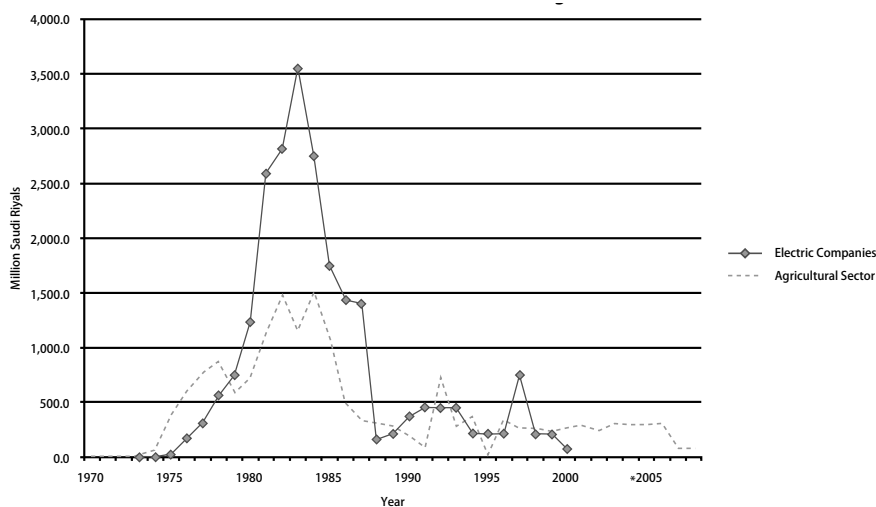
6.4. Governmental Subsidy

Governmental subsidies are both direct and indirect [Wilson & Al-Rajhi 2004]. An example of an indirect subsidy is, for example, that the government guarantees 7–15% profit to power businesses to invite private investment. A direct subsidy is provided by setting the electricity tariff low. Figure 20 shows the trend of direct subsidies [MEP 2011].²¹ The very special feature of this graph is the high subsidies around 1983. It seems that this peak came from two causes. One was the ballooning fuel costs caused by installing small diesel generators in rural areas, which were not covered by the power grid, to meet to electrification demands. The other came from the similar subsidy peak for agriculture shown by the dotted line in Figure 20, caused by the governmental policy of those days to improve self-sufficiency in food production, which lead to an increase in the use of water pumps for farm irrigation and hence an increase in electricity demand. Electricity prices for agriculture were cheap but the farms located in remote rural areas depended on costly diesel generation. Later these two subsidies were synchronized, and with the network expansion and decrease in subsidies for agriculture, direct subsidies to power companies decreased.

In 1995 the government announced its privatization policy for the power sector and has made efforts to realize the sound management of power companies without subsidies in order to transfer them to viable private capital ventures. Since 1994, the government had granted an annual subsidy of 210 million SR, except in 1997 when they granted 746 million SR, and then finally in 2001 the subsidy officially ceased. However as was shown in the previous section SEC still has a deficit, so we might infer that some governmental support to SEC continues unofficially.

²¹ In addition to direct subsidies, SEC receives governmental loans through Saudi industrial Development Fund (SIDF) to construct generating plants, transmission lines, substations and so on.

Figure 20: Governmental Subsidy for Electricity and Agriculture [MEP 2011]

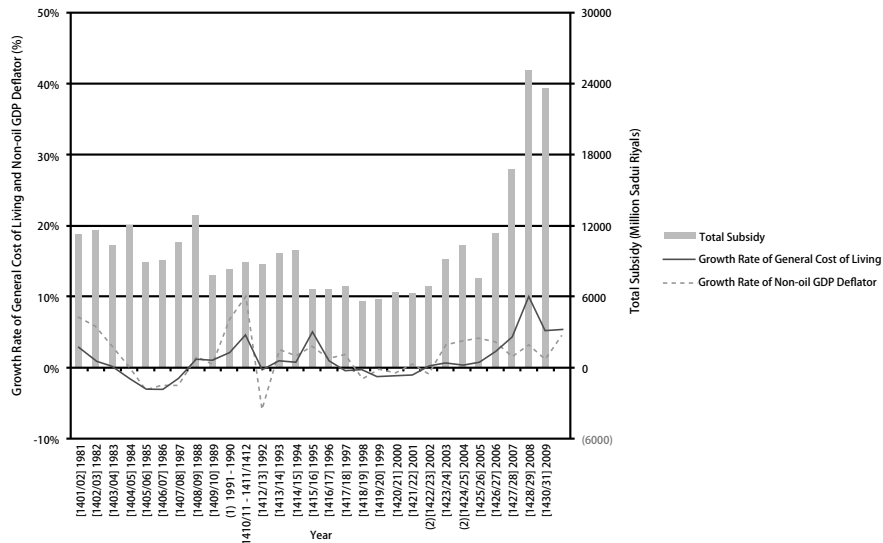


One year before the price rise in 2011, financial support for low-income families was started. With this subsidy 220 thousand families received social aid for electricity and food. The Ministry of Social Affairs earmarked SR 103 million for food allowances for the month of Rajab (mid-June to mid-July), while SR 30 million was set aside for the payment of electricity bills [Saudi Gazette 2011]. Support for low-income families was largely improved because total social aid subsidies rose sharply from 3.011 billion SR in 2005 to 13.663 billion SR in 2007.

Governmental subsidies are wide ranging. They are not only for electricity but also imported food such as barley, agriculture such as wheat production, social aid, and so on. These subsidies are officially supports for low-income families and really intended to distribute the country's vast oil income among the people. But with these subsidies, daily essentials such as water, gasoline, electricity, wheat and milk have been very cheap and accordingly it became possible to hire foreign workers at low salaries [Al-Yousef & Stevens 2011]. As for example in Qatar, water and electricity are free of charge for Qatar citizens but foreign workers have to buy them, Al-Yousef and Stevens have suggested establishing different tariff systems for Saudis and non-Saudis [Al-Yousef & Stevens 2011].

Oil producing states such as Saudi Arabia which are called the Rentier States, can maintain the stability of their administration by distributing their oil wealth. One of these distribution paths is through subsidies, but it should be mentioned that a subsidy is an anti-inflation measure. Figure 21 shows the inflation index, growth rate of cost of living and non-oil GDP deflator with line graphs, and total subsidies with a bar chart [SAMA 2011].

Figure 21: Inflation Index and Total Subsidy [SAMA 2011]



With a falling inflation index, the total of subsidies decreases and with a rising trend it increases. Generally anti-inflation measures consists of (1) financial restraint (raising of central bank rate), (2) cuts in financial expenditure, (3) depression of consumer spending, and (4) exchange rate appreciation. However, Saudi Arabia's Riyal is pegged to the US dollar and it is difficult to change the exchange rate and the central bank rate independently from the US. Furthermore as the country does not impose income tax there no way to raise taxation. The last measure is to cut financial expenditure but because of a dependency on imported goods, the government is obliged to provide subsidies to decrease the cost of living. This is a contradiction, but it is clearly very hard for an oil producing country, which is tightly linked to the world economy, to administrate and manage an overheated economy. Therefore subsidies may be the last resort.

7. Domestic Energy Policy of Saudi Arabia

Based on the investigation and analysis in the previous sections, Saudi Arabia's domestic energy policy is summarized as follows;

- 1) In achieving modernization, there were virtually no limitations on domestic energy use. The constraint was in the infrastructure to generate and distribute the energy, and with huge oil income, a domestic energy system was established extremely rapidly.
- 2) The next issue was the diversification of industry, and to encourage the development of private companies, the government set a very low electricity price for industry.

- 3) Natural gas is only for local use, in power generation for producing feedstock, petrochemical plants, and desalination.
- 4) The power sector started as a purely private business, then the government took a share in 1970s and it was converted into a state owned company, but now it is once more under privatization and horizontal separation. While the government was driven by necessity to make the power sector public, the water sector, in contrast has always been owned and operated by the government until recently.
- 5) To invite private investment and ensure a lower price, a subsidy has been provided to the power sector.
- 6) In the latest tariff system, electricity prices were raised for the commercial sector and the TOU tariff was introduced for the industrial sector.

It is very interesting to know that government hopes to encourage private investment in the power sector. Generally in the Arab world, a huge investment is regarded as high risk, so a subsidy may be necessary to overcome a negative business environment. However, as a very limited number of persons can actually benefit from this subsidy, then it might lead to crony capitalism or be one of distribution channels for the oil income. Even in the present day it is said that IPP business cannot obtain a project without involving a member of the Royal Family.

The difference in the degree of governmental involvement between the power and water sectors is interesting too. Water is the most important commodity in the desert and the government recognized its critical responsibility for water management. As modernization has progressed, the importance of electricity in the non-industrial sector has increased and has now become a new Basic Human Need in this country. The government has to try to maintain a stable supply at a reasonable price.

The price of water and electricity are kept very low by huge subsidies. In Saudi Arabia there is unwritten social contract between the governor and the governed within the fundamental political system [Al-Yousef & Stevens 2011]. The governor and the elite class govern the state with minimum consultation with the governed. To keep cheap utility prices is the nation's will, and if jeopardized drastic measures have to be taken, as happened in 2000, when the price rise had to be withdrawn after only 6 months. Subsidies to compensate negative net worth were the cost of promoting modernization in the initial stages, but now they have become a very strong impediment. Taking this background into consideration, the tariff change in 2011 was epoch making. To correspond to the urgent issue, peak cut/shift, the TOU tariff was introduced successfully. Meanwhile, price rises for the commercial sector can be taken as evidence of the existence of a consumer society as shown in Figure 15. However, there still much to be done. The unwritten social contract may be very tough, but price rises

for the residential sector are necessary. It will be a hard task but it is clearly necessary to provide this nation with a sustainable economy.

8. Conclusion

The history, policy, detailed situation and issues of the Saudi Arabia's domestic energy, especially electricity, have been analyzed. These topics have seldom been studied in academic articles. Since Saudi Arabia has not publicized its own comprehensive energy plan, this article contributes to the energy policy analysis of Saudi Arabia.

This country is important internationally, since it has produced and exported oil for the world economy. Oil has been essential to the development of the world's industries, both as a fuel (heat source) and for its byproducts. Moreover, its importance has increased since 1990, because of the development of the IT society and the global economy. IT is maintained by electricity, which is generated mainly using oil, and the global economy needs efficient logistics, which are fuelled by oil. We can say that a modernized society would be brain dead and the global economy would collapse without sufficient energy supplies. Saudi Arabia has become the major "utility state" for the world economy. For this reason Saudi Arabia has always been the center of attention in terms of its oil supply and it has made responding to the world's (or West's) expectations as a swing producer its first priority by sacrificing better resource utilization plans for its own sake. Of course, a major reason why Saudi Arabia could do this is its abundant oil resources. It could utilize its oil to modernize its society without paying heed to the cost.

Here are the answers to the questions raised in the introduction. Saudi Arabia has intended to support and develop its non-oil industries through lower energy prices. However, excessive non-industrial energy use has become a major obstacle. The power sector was developed basically by private businesses with government support. Because of the growing peak demands there have been difficulties in maintaining domestic supplies, and wide area grid operation has not been realized. Energy saving and peak shift/cut have become urgent issues and to solve them, the tariff system was changed in 2011.

Now Saudi Arabia has increasing local energy consumption. It is a serious issue and indicates one of Saudi Arabia's structural paradoxes. It became a modernized country by exporting its vast oil resources to international consumers, but due to the resulting rapid growth it is now consuming ever increasing amounts of its own resources.

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